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REPORT ON THE ACOUSTIC TRANSMISSION AND VIBRATION DAMPING CHARA--ETC(U)

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TECHNICAL MEMORANDUM

U.S. NAVAL APPLIED SCIENCE LABORATORY
FLUSHING & WASHINGTON AVES.
BROOKLYN, NEW YORK 11251

USNASL-9110-P-1J(REV. 10-64)

(1)

(6) REPORT ON THE ACOUSTIC TRANSMISSION
AND
VIBRATION DAMPING CHARACTERISTICS
OF
MATERIALS FOR USE ON ACOUSTIC WINDOWS
OF SONAR DOMES.

Lab. Project IED-11 (9) Technical Memo~~randum~~ 1

(11) 25 AUG 1966

(12) 17p.

MATERIAL SCIENCES DIVISION

(14) NASL-IED-11-TM-1

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Lab. Project IED-11
Technical Memorandum 1

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ADMINISTRATIVE INFORMATION

Ref: (a) NASL Program Summary of 1 May 1966, "Acoustically transparent damping materials", Lab. Project IED-11, (pp 623-626)
(b) NAVAPLSCIENLAB Project 9300-16, Tech Memo 11 of 1 Apr 1965
(c) NAVAPLSCIENLAB Project 9300-16, Tech Memo 8 of 3 Nov 1964
(d) NAVAPLSCIENLAB Project 9300-16, Tech Memo 3 of 6 Dec 1963
(e) Spec. MIL-S-24062A (Ships) of 15 Nov 1965; Sprayable Vibration Damping Material for Surface Vessels

INTRODUCTION

1. The development of an acoustically transparent vibration damping material for sonar domes as described in reference (a) is continuing at the U. S. Naval Applied Science Laboratory.

2. This report presents the underwater acoustic transmission and vibration damping characteristics of eight experimental NASL - developed materials, intended for use in sonar domes.

BACKGROUND

3. Although instrumentation for sonar detection has progressed to a fairly advanced stage, the presence of interference noise still remains the fundamental controlling factor in establishing sonar range and accuracy. Some of the interference noise is transmitted to the sonar transducers as a result of vibrations due to hydrodynamic or structure-borne excitations in the hull-mounted sonar dome itself. One of the methods currently used to reduce the vibrations in the AN/SQS-23 sonar dome is to fill its lower section, below the acoustic "window", with approximately 5-6 inches of Ottawa sand and to blanket this sand with foamed-in-place, high density polyurethane foam. However, field reports have indicated that the foam blanket loosened and permitted water to penetrate the sand. This water penetration, coupled with movement of the sand, resulted in both corrosion and erosion degradation of the dome and decreased damping efficiency. In order to overcome this difficulty, and in view of the successful development of the ML-D2 viscoelastic vibration damping tiles at NASL, the Laboratory undertook the development of a sprayable vibration damping material for use in sonar domes. Such a sprayable material designated as ML-SD15 was developed. Service applications of the material were made on the domes of the USS RICH (DD-820) and the USS MAC KENZIE (DD-836). The results of the service tests as reported in reference (d) indicated that the performance of the domes damped with the ML-SD15 material was essentially equal to or better than domes damped with the sand foam system. It was

also demonstrated that application of damping material to all of the dome surface, heretofore not feasible with the sand treatment, would provide markedly improved damping of the dome structure. However, an overall application of ML-SD15, covering the acoustic "window" of the dome, would result in excessive signal attenuation. Therefore, in view of the dome performance gains to be achieved, NASL has undertaken a program to develop materials which will exhibit both vibration damping and acoustic transparency characteristics. Furthermore, the vibration damping gains to be achieved by complete dome coverage are of such a degree that some trade-off between these two characteristics may be tolerated. The continuing search for acoustically transparent, vibration damping materials is being guided by these stated premises.

MATERIALS INVESTIGATED

4. The investigation was conducted on eight NASL developed formulations which employed commercially available epoxy, polyamide and polyurethane resins, and various fillers. The formulations were as follows:

a. Formulation 15-12

Ingredients	Parts by Weight
General Mills, Inc., Versamid 112, polyamide	100
Shell Chemical Co., Epon 828, epoxy	37.5
Rohm and Haas Co., DMP-30	7.5

b. Formulation 15-13

Ingredients	Parts by Weight
Spencer Kellogg Co., M-80-50-CX, polyurethane	100
Shell Chemical Co., Epon 828, epoxy	75
Joseph Dixon Crucible Co., No. 1102, graphite filler	75
Rohm and Haas Co., DMP-30	4

c. Formulation 15-14

Ingredients	Parts by Weight
Spencer Kellogg Co., XP1418, polyurethane	65
" " " M-80-50-CX, polyurethane	35
Shell Chemical Co., Epon 828, epoxy	50
Rohm and Haas Co., DMP-30	2.5

d. Formulation 15-15

Ingredients	Parts by Weight
Spencer Kellogg Co., M-80-50-CX, polyurethane	100
Shell Chemical Co., Epon 828, epoxy	50
Regency Rubber Co., butyl rubber filler, approx. 60 mesh	75
Rohm and Haas Co., DMP-30	4

e. Formulation 15-20

Ingredients	Parts by Weight
Spencer Kellogg Co., XP1418, polyurethane	65
" " " M-80-50-CX, polyurethane	35
Shell Chemical Co., Epon 828, epoxy	75
Regency Rubber Co., butyl rubber filler, approx 60 mesh	75
Rohm and Haas Co., DMP-30	4

f. Formulation 15-23

Ingredients*	Parts by Weight
Shell Chemical Co., Epon 828, Epoxy	20
General Mills Co., Versamid 115, Polyamide	100
Rohm & Haas Co., DMP-30 Polyamine	5
Koppers Co., Inc. Halowax 4004, Chlorinated Wax	42
City Chemical Co., Technical grade Antimony Trioxide	14
Axel Plastic Research Lab., Flow Whiz No. LAIS	29
Peerless Oil & Chemical Co., Cellusolve	12
Bakelite Corp. - Phenolic Microballon Filler	3.0

*Note: This was the ML-SD15 formulation of reference (e) with microballons substituted for the conventional fillers.

g. Formulation 15-24

Ingredients	Parts by Weight
General Mills Inc. Versamid 115, polyamide	150
Shell Chemical Co., Epon 828, epoxy	37.5
Joseph Dixon Crucible Co., No. 1102, graphite filler	85
Rohm and Haas Co., DMP-3	9

h. Formulation 15-28

Ingredients *	Parts by Weight
Shell Chemical Co., Epon 828, Epoxy	20
General Mills Co., Versamid 115, Polyamide	100
Rohm & Haas Co., DMP-30, Polyamine	5
Koppers Co., Inc. Halowax 4004, Chlorinated Wax	42
City Chemical Co., Technical grade Antimony trioxide	14
G. Pattinos Sand Co., Pattinos #57-80 mesh Cab-O-Sil	12
Axel Plastic Research Lab. Flow Whiz No LAIS	29
Peerless Oil & Chemical Co., Cellusolve	12

*Note: This was the ML-SD15 formulation of reference (e) with sand omitted.

5. The ML-SD15 formulation, and 1/8 inch thick butyl rubber sheet material were included as comparison "controls", for vibration damping characteristics, and for acoustic transmission characteristics, respectively. A curve considered representative of ML-SD15 vibration damping characteristics determined by the 15 inch beam method, was included for comparison purposes on Figures 5 through 8. The 15 inch beam method, used in this study, is to be recommended by NASL for inclusion in the Specification, reference (e). Test formulations 15-23 and 15-28, except for changes in fillers, were prepared by the conventional mixing technique used for ML-SD15. Damping data for similarly prepared specimens having these same formulations, were reported earlier in reference (b).

PROCEDURE

6. Sound Transmission - The NASL underwater sound transmission measuring facility, as described in reference (c), was used to measure the sound transmission reduction of the materials under test. The materials were coated on one side of 30" X 30" X 1/16" steel panels with the coating facing the interior of the chamber. The electrical input to the random noise projector, inside the chamber, was maintained constant (at 10 volts and 13 milliamps) for all measurements made. The sound pressure level at the receiving hydrophone located outside the chamber, was analyzed in 1/3 octave bands. The reduction in sound transmission was obtained from the difference in the sound pressure levels (at the receiving hydrophone) measured for coated and uncoated panels.

Note: The acoustic transparency of a material is reported in terms of "sound transmission reduction"; for example, low transmission reduction implies high transparency.

7. Vibration Damping - Evaluation of the damping characteristics of the materials was determined by the decay rate of vibration of a coated steel beam, 15" long, 1 1/2" wide, and 3/8" thick as described in reference (b).

8. One specimen for sound transmission and one specimen for vibration damping was prepared with the formulations outlined in paragraph 4, above. Each specimen was prepared by open mold casting a 5/8 inch thickness of material directly to the surface of a plate or beam. Prior to the preparation of the test specimens, the 30" X 30" steel panels and the 15 inch beams were cleaned by sandblasting and primed by coating with Navy formula 117 wash primer. All measurements were made on the formulations after curing for a minimum of four days at 23°C.

RESULTS

9. Sound Transmission Characteristics - The transmission reduction results obtained for the eight materials evaluated are shown in Figures 1, 2, 3, and 4.

10. Vibration Damping Characteristics - The vibration damping results obtained for the eight materials evaluated are shown in Figures 5, 6, 7 and 8.

DISCUSSION OF TEST DATA

11. The sound transmission loss characteristics for all formulations in this study were considered high compared with the characteristic of the butyl rubber "control" specimen, and too high for practical sonar dome use. Some speculation can be made to explain these results. It is surmised that air which may have been entrapped during mixing of the polyamide - epoxy formulations, failed to escape from the viscous mass during cure, caused formation of voids. It is also surmised, for the polyurethane - epoxy formulations, that moisture may have reacted with the urethane to produce gas voids. Where fillers were used, reduced wettability of the fillers may also have contributed to formation of voids. It is reasonable to assume that a reduction in these voids could result in appreciable reductions in the sound tranmission loss properties.

12. The ML-SD15 material, and Formulas 15-23 and 15-28 showed a greater sound transmission reduction than was previously reported in reference (b). Examination of these materials showed a greater amount of voids than was found in the reference (b) specimens.

13. Formula 15-24 in which graphite was used as a filler, showed the lowest sound transmission loss, between 700 and 3000 cps, of all the formulations evaluated.

14. Formulas 15-15 and 15-20 in which powerdered butyl rubber of approximately 60 mesh was used to enhance the sound transmission property, showed the highest sound transmission loss of all the materials evaluated, Examination of the specimens showed that the formulation had formed into a foamy mass. This foaming is attributed to the inability to "wet" the irregular surfaces of the buty rubber particles; to the introduction of moisture from the air which is whipped into the formulation during the mixing procedure; and to moisture which may have been attached to the rubber particles.

15. The vibration damping properties of all formulations tested, in the 300 to 7500 cps range, were considerably higher than those of the butyl rubber but somewhat lower than those of ML-SD15 used as the damping control. In this respect all formulations can be considered promising candidates for the trade-off of properties discussed in paragraph 3, above. The most promising of these was the Formulation 15-24 which compared favorably with ML-SD15 in vibration damping and which showed the lowest overall transmission loss property. Several other formulations appeared promising to a much lesser degree, and, of these, the Formulation 15-13 would bear further study because of its graphite filler.

CONCULSION

16. All of the formulations, as prepared for this study, were unacceptable for complete sonar dome coverage based on high sound transmission loss properties.

17. Material preparation techniques to reduce void formation was indicated as a means for reducing sound transmission losses.

18. The use of graphite fillers was indicated as a means for improving the desired damping and sound transmission characteristics.

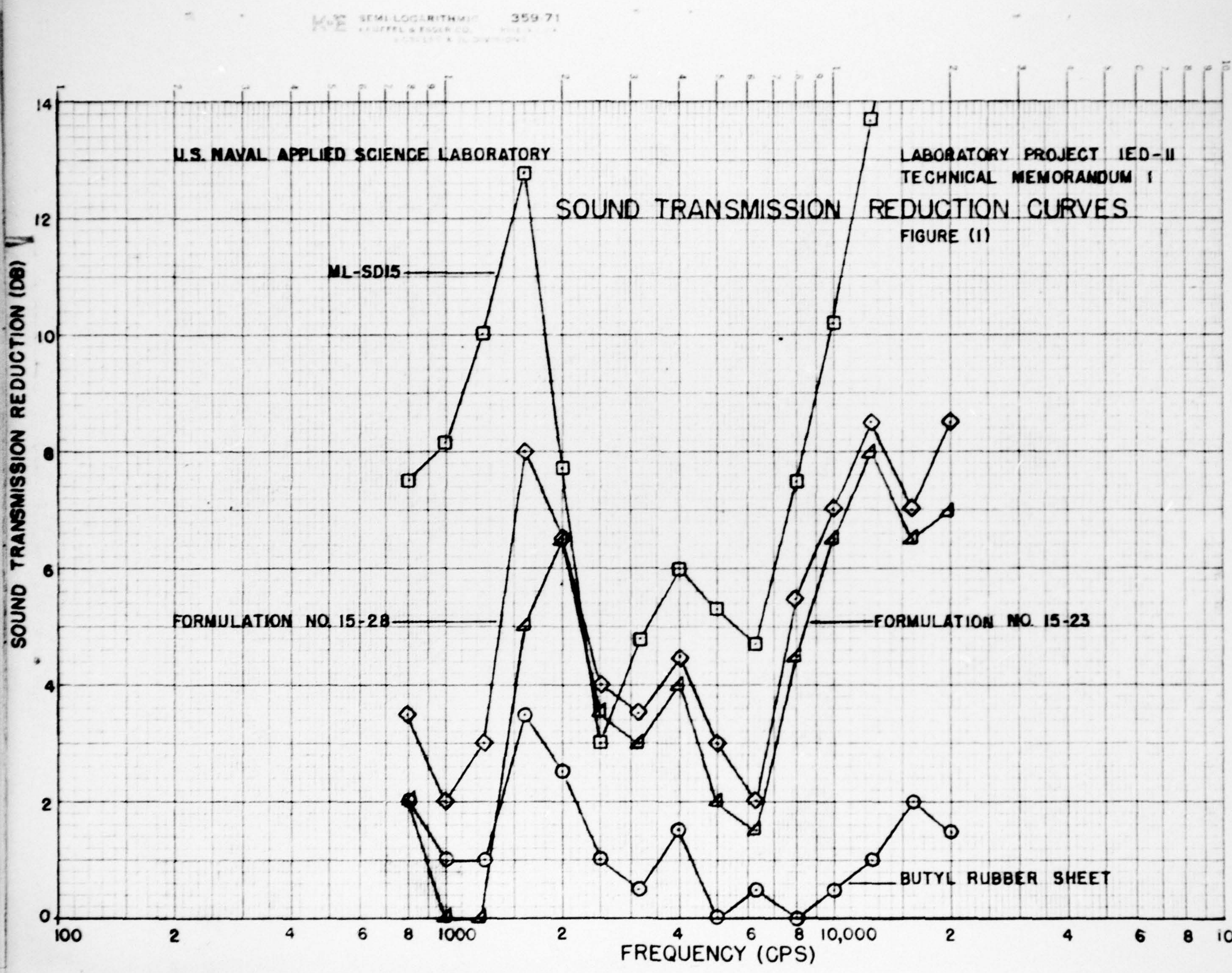
19. Formulation 15-24, and possibly 15-13, were considered the most promising candidates for pursuing the indicated development of an improved preparation technique and for study of graphite filler effects.

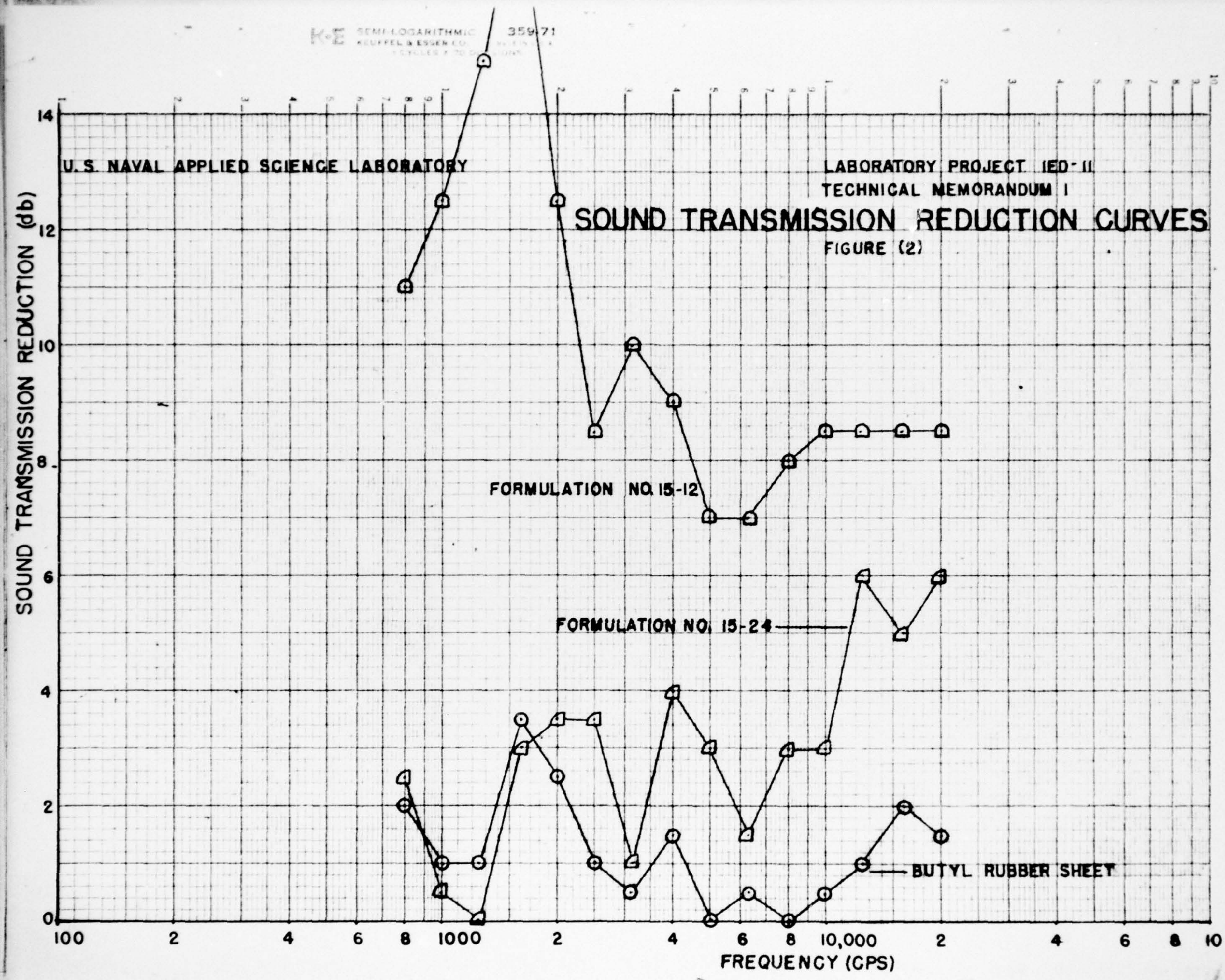
FUTURE WORK

20. Work on the development of an acoustically transparent damping material will continue as follows:

a. Develop a preparation technique and method of application which would more effectively control void formation.

b. Conduct further investigations of the effect of various types of graphite fillers in polyamide-epoxy and polyurethane systems on the acoustical transmission and damping properties with the view of improving the characteristics of such formulations as 15-13 and 15-24.


U.S. NAVAL APPLIED SCIENCE LABORATORY
LABORATORY PROJECT IED-II
TECHNICAL MEMORANDUM 1
SOUND TRANSMISSION REDUCTION CURVES
FIGURE (1)
ML-SD15
FORMULATION NO. 15-28
FORMULATION NO. 15-23
BUTYL RUBBER SHEET
SOUND TRANSMISSION REDUCTION (DB)
FREQUENCY (CPS)
0
2
4
6
8
10
12
14
100
2
4
6
8
1000
2
4
6
8
10,000
2
4
6
8
100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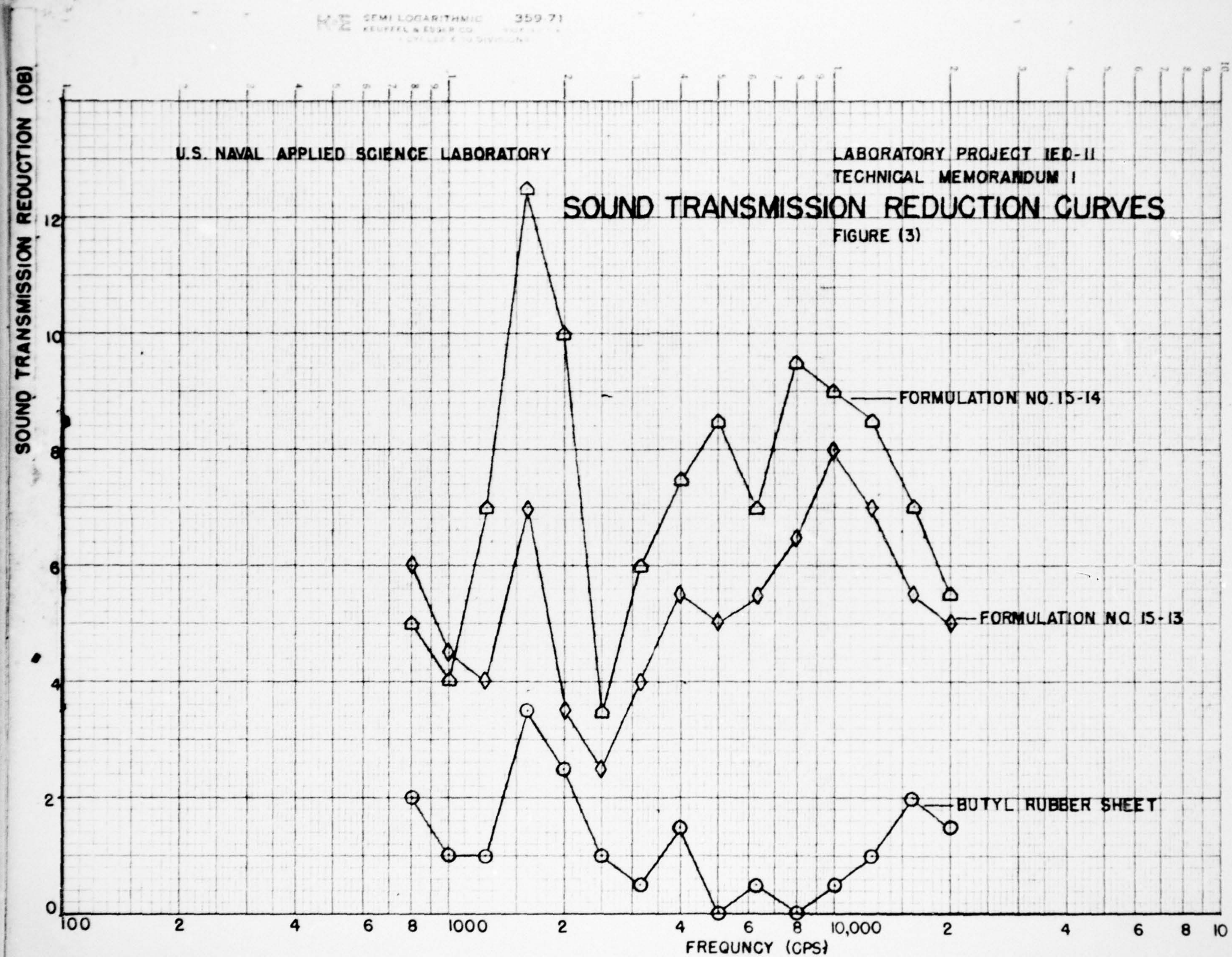
LABORATORY PROJECT IED-11
TECHNICAL MEMORANDUM 1
SOUND TRANSMISSION REDUCTION CURVES
FIGURE (2)
FORMULATION NO. 15-12
FORMULATION NO. 15-24
BUTYL RUBBER SHEET
SOUND TRANSMISSION REDUCTION (db)
FREQUENCY (CPS)
0
2
4
6
8
10
12
14
100
2
4
6
8
1000
2
4
6
8
10,000
2
4
6
8
10
K+E SEMI-LOGARITHMIC 359-71
KEUFFEL & ESSER CO.



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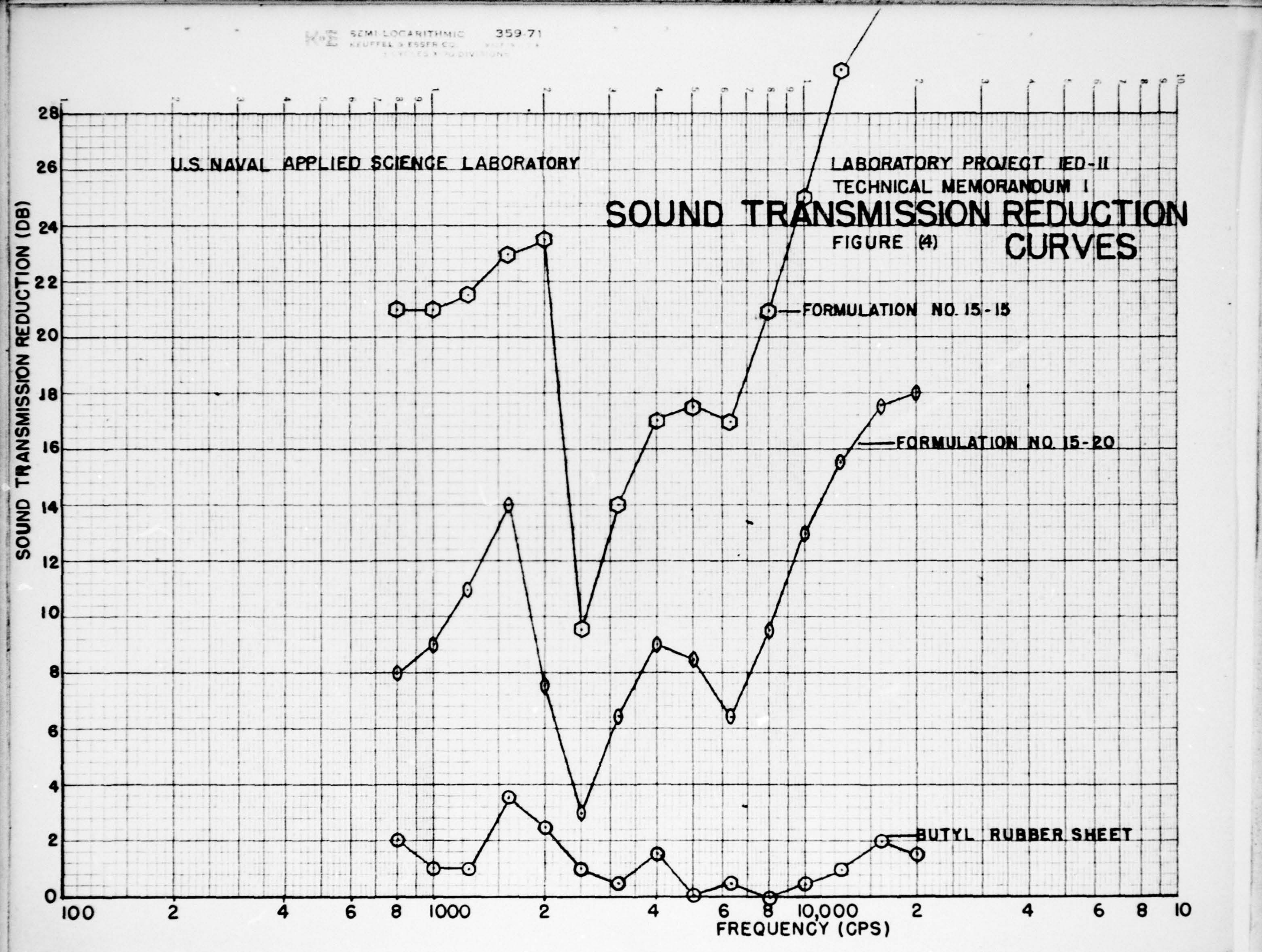
LABORATORY PROJECT IED-11
TECHNICAL MEMORANDUM 1
SOUND TRANSMISSION REDUCTION CURVES
FIGURE (3)
FORMULATION NO. 15-14
FORMULATION NO. 15-13
BUTYL RUBBER SHEET
SOUND TRANSMISSION REDUCTION (DB)
FREQUNCY (CPS)
0
2
4
6
8
10
12
100
1000
10,000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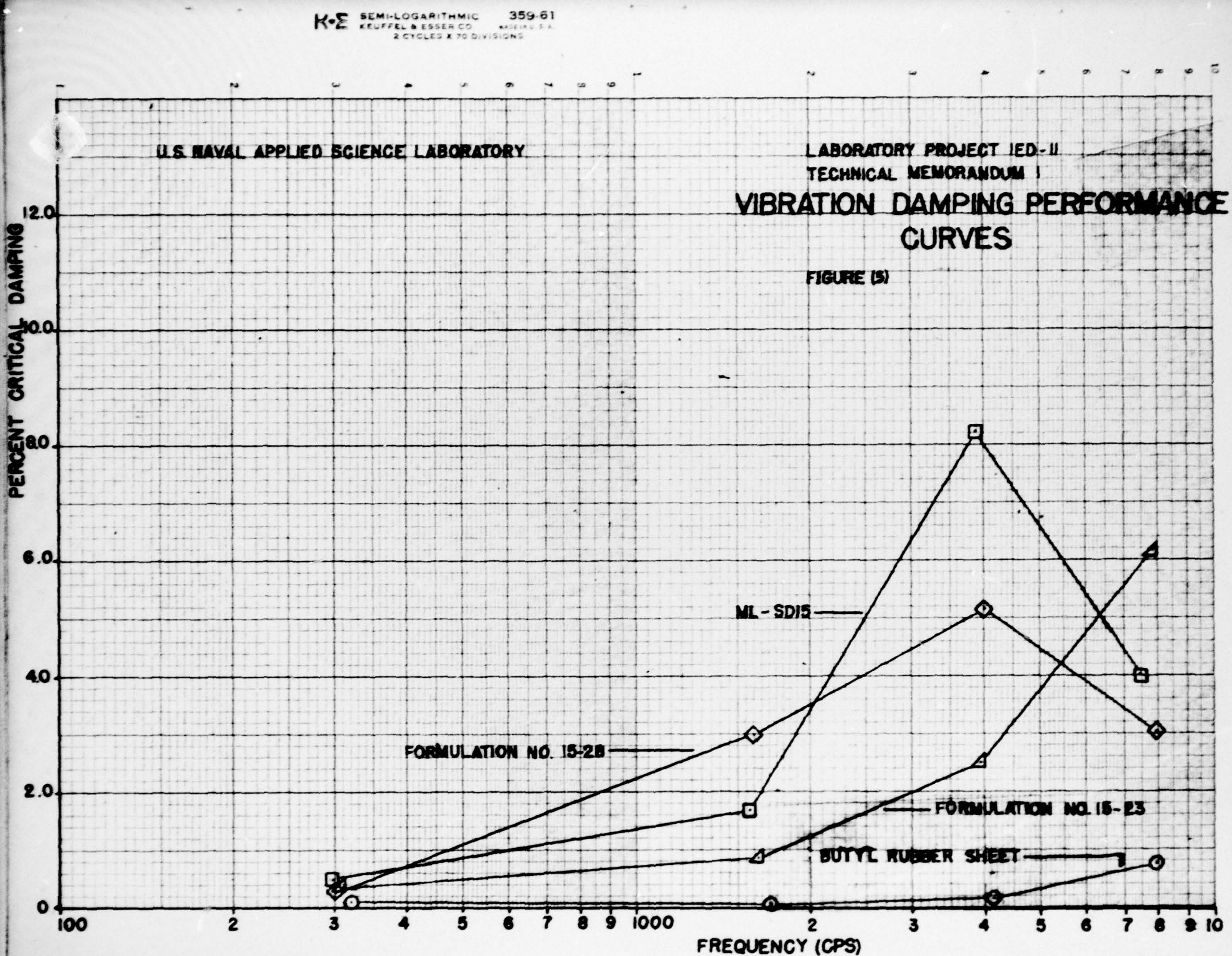
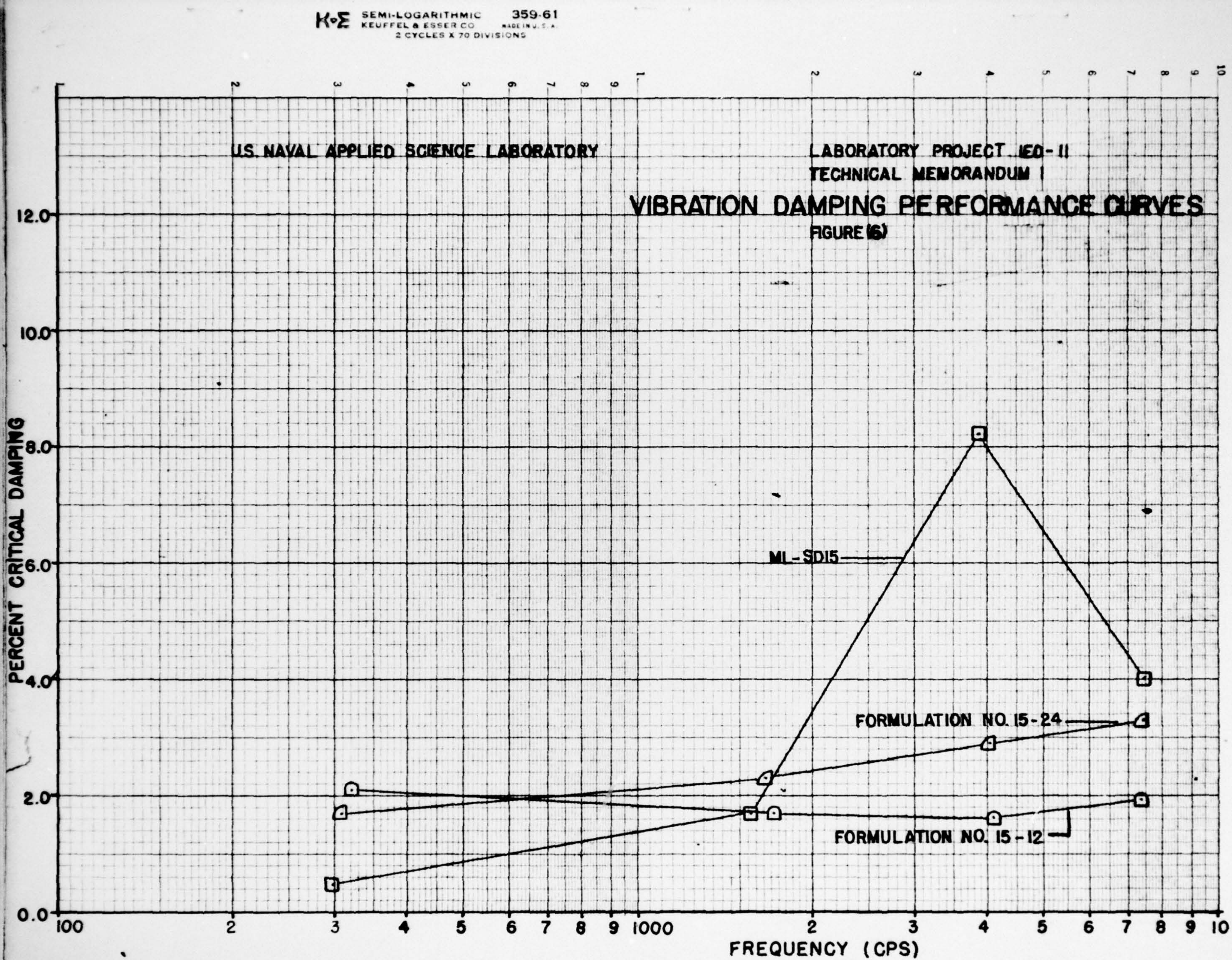
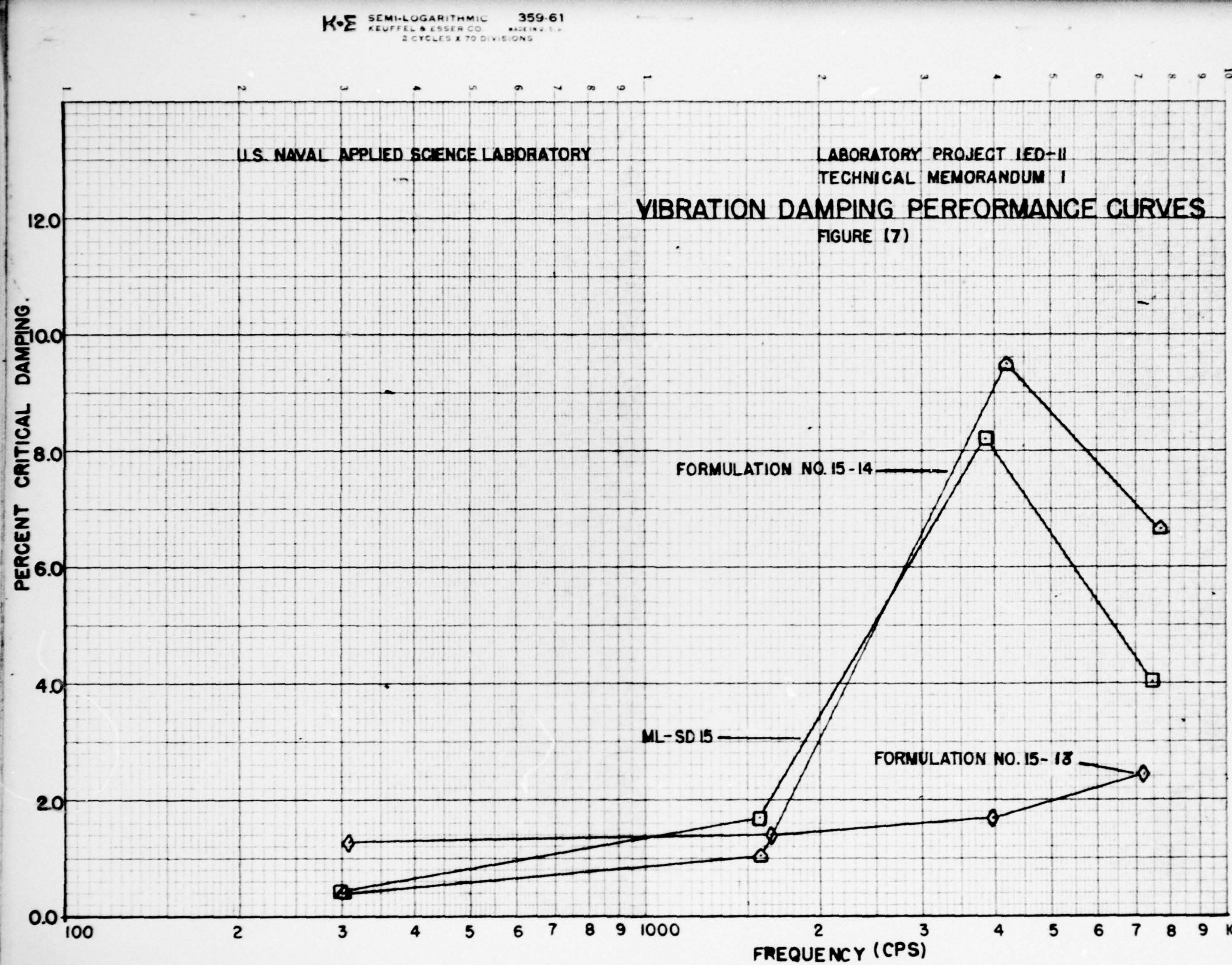
LABORATORY PROJECT IED-II
TECHNICAL MEMORANDUM I
SOUND TRANSMISSION REDUCTION CURVES
FIGURE (4)
FORMULATION NO. 15-15
FORMULATION NO. 15-20
BUTYL RUBBER SHEET
SOUND TRANSMISSION REDUCTION (DB)
FREQUENCY (CPS)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
100
2
4
6
8
1000
2
4
6
8
10,000
2
4
6
8
10
SEMI-LOGARITHMIC 359-71
KEUFFEL & ESSER CO.


K·E SEMI-LOGARITHMIC 359-61
KEUFFEL & ESSER CO.
2 CYCLES X 70 DIVISIONS
U.S. NAVAL APPLIED SCIENCE LABORATORY
LABORATORY PROJECT IED-II
TECHNICAL MEMORANDUM I
VIBRATION DAMPING PERFORMANCE CURVES
FIGURE (5)
ML-SD15
FORMULATION NO. 15-28
FORMULATION NO. 15-23
BUTYL RUBBER SHEET
PERCENT CRITICAL DAMPING
FREQUENCY (CPS)
0
2.0
4.0
6.0
8.0
10.0
12.0
100
1000



K+E SEMI-LOGARITHMIC 359-61
KEUFFEL & ESSER CO. MADE IN U.S.A.
2 CYCLES X 70 DIVISIONS
U.S. NAVAL APPLIED SCIENCE LABORATORY
LABORATORY PROJECT IED-11
TECHNICAL MEMORANDUM 1
VIBRATION DAMPING PERFORMANCE CURVES
FIGURE (6)
ML-SD15
FORMULATION NO. 15-24
FORMULATION NO. 15-12
PERCENT CRITICAL DAMPING
FREQUENCY (CPS)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
100
2
3
4
5
6
7
8
9
1000
10


K•E SEMI-LOGARITHMIC 359-61
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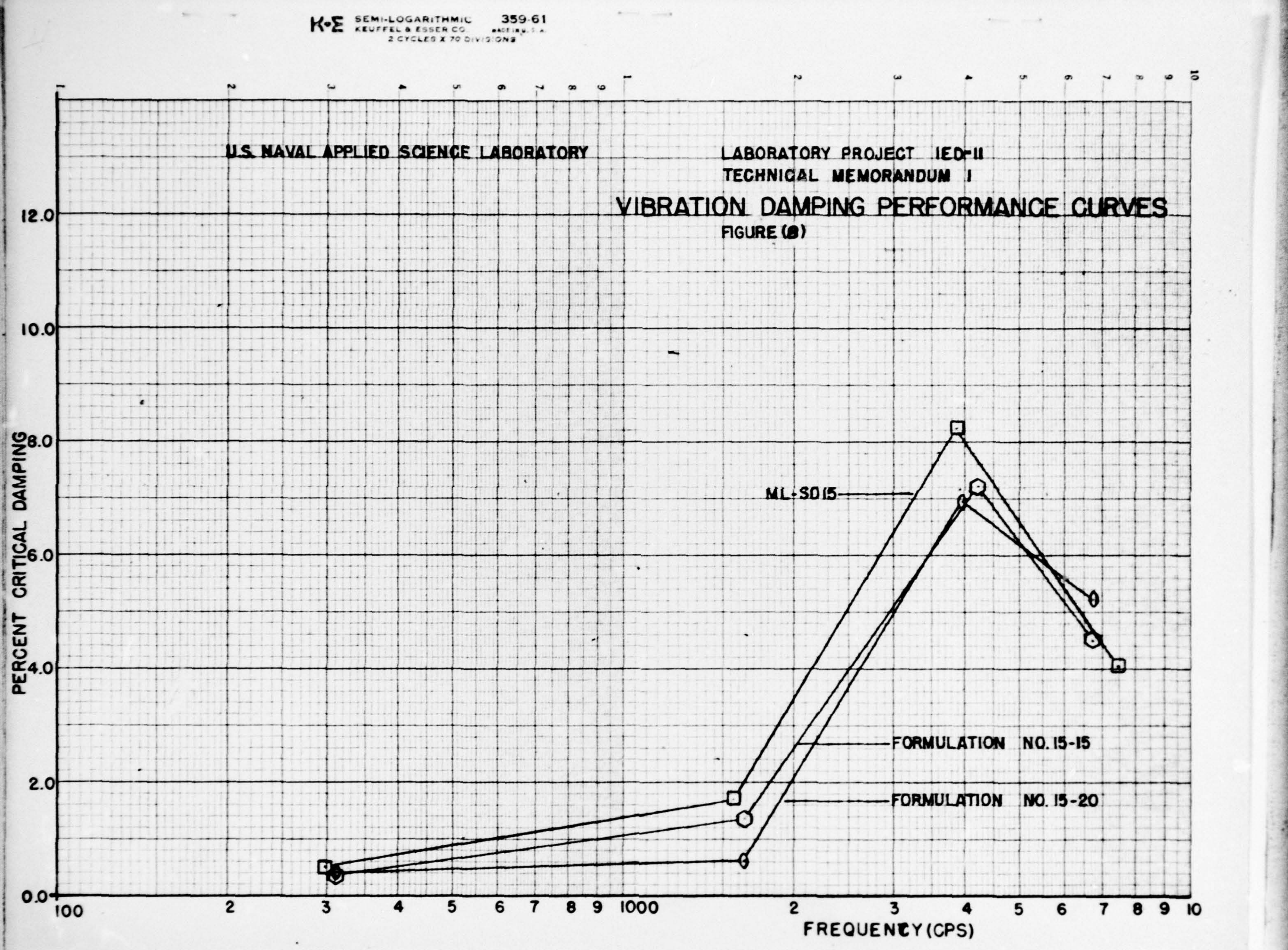
2 CYCLES X 70 DIVISIONS
U.S. NAVAL APPLIED SCIENCE LABORATORY
LABORATORY PROJECT LED-11
TECHNICAL MEMORANDUM 1
VIBRATION DAMPING PERFORMANCE CURVES
FIGURE (7)
PERCENT CRITICAL DAMPING.
12.0
10.0
8.0
6.0
4.0
2.0
0.0
FORMULATION NO. 15-14
ML-SD 15
FORMULATION NO. 15-18
100
2
3
4
5
6
7
8
9
1000
2
3
4
5
6
7
8
9
10
FREQUENCY (CPS)


K·E SEMI-LOGARITHMIC 359-61
KEUFFEL & ESSER CO.
2 CYCLES X 70 DIVISIONS
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LABORATORY PROJECT IED-II
TECHNICAL MEMORANDUM I
VIBRATION DAMPING PERFORMANCE CURVES
FIGURE (8)
ML-SD15
FORMULATION NO. 15-15
FORMULATION NO. 15-20
PERCENT CRITICAL DAMPING
0.0
2.0
4.0
6.0
8.0
10.0
12.0
100
1000
FREQUENCY (CPS)